Climate Induced Hatchery Upgrades

Nimbus Hatchery

Alternatives Analysis Submittal

Final Report
Revision No. 4

McMillen

February 2025

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Revision Log

Revision No.	Date	Revision Description
0	04/25/2024	65% Draft for Internal Technical Review
1	05/03/2024	65% Draft for CDFW Review
2	08/30/2024	100% Draft for CDFW and Internal Review
3	10/31/2024	Final Submittal to CDFW
4	02/14/2025	Final Submittal to CDFW, ADA Accessible Document

Appendices

The appendices that accompany this document are not ADA compliant. For access to the following appendices, contact Fisheries@wildlife.ca.gov. If assistance is needed for an ADA compliant version of the appendices, please include that in the email.

- Appendix A. Site Visit Report
- Appendix B. Bioprogramming
- Appendix C. Concept Alternative Drawings
- Appendix D. Design Criteria TM
- Appendix E. Alternatives Development TM
- Appendix F. Cost Estimates
- Appendix G. Meeting Minutes
- Appendix H. LEED and NZE Evaluations

Executive Summary

McMillen, Inc. (McMillen) was retained by the California Department of Fish and Wildlife (CDFW) to provide an assessment of 21 CDFW fish hatcheries throughout the State of California in the context of their vulnerability to the effects of climate change. Climate modeling was performed by Northwest Hydraulic Consultants (NHC).

The Nimbus Hatchery has an aging infrastructure and multiple deficiencies that need to be addressed in the near future to meet fish production goals. Water temperatures at the Nimbus Hatchery are too high for egg incubation and early rearing during certain periods of the year. Staff have retrofitted existing rearing infrastructure with individual chilling units, but this system has a limited ability to adapt for future changes. Additionally, the production raceways are affected by severe leakage, and the surrounding asphalt is prone to sinkhole formations. Sinkholes affect equipment access for marking and feeding operations, and leakage in the raceways likely exacerbates the erosion.

The preferred alternatives identified in this report include improvements to the water supply and installing water treatment equipment including oxygenation and filtration. Oxygenation would allow the facility to counteract changes in water quality parameters like those experienced in the fall of 2023 when the fish ladder had a delayed opening due to low oxygen levels. Filtration would improve water quality for incubating eggs and early life stages, as well as improve the efficiency of any UV disinfection systems. Selected alternatives also include water chilling for both hatchery buildings, as well as chilling for a new partial recirculating aquaculture system (PRAS) to replace the raceways. The PRAS would efficiently use chilled water, reducing energy demands associated with chilling, and be constructed on a solid foundation to eliminate issues associated with the current subgrade. These improvements would actively manage increasing water temperatures and allow CDFW staff to maintain acceptable rearing conditions. This would reduce the need for fish evacuations, which can lead to increased rates of straying and have negative impacts on wild populations of anadromous fish. Where feasible, all major improvements would include flow meters, low flow alarms, and upgraded power systems to ensure new equipment can operate smoothly.

The Class 5 Opinion of Probable Construction Cost (OPCC) for constructing the preferred alternative upgrades can be found in the table below (Table 6-2 provides the Class 5 OPCC summary). The table also includes the estimated cost of photovoltaic systems to offset the energy consumption of the new equipment and to maintain zero net energy. These upgrades would not significantly affect fire or flood risks at the facility, and all work would occur within already developed areas. Operationally, CDFW would need to update feeding, harvesting, and water quality monitoring protocols to accommodate the transition to partial recirculating aquaculture systems with circular tanks. The proposed upgrades would provide a solid foundation for CDFW to sustain fish production at the hatchery, even as climate change increasingly disrupts current and future operations.

Project Total	Photovoltaic – Zero Net Energy
$51,730,000	$21,699,900

1.0 Introduction

1.1 Project Authorization

McMillen, Inc. (McMillen) was retained by the California Department of Fish and Wildlife (CDFW) to provide a climate change evaluation for 21 hatcheries operated by CDFW throughout the State of California. The contract for this Climate Induced Hatchery Upgrade Project (Project) was executed on March 21, 2023.

1.2 Project Background

California relies on CDFW hatcheries to provide recreational fishing opportunities for the public and for the conservation of endangered or threatened species. However, climate change threatens the business-as-usual production of fish with the existing CDFW hatchery infrastructure. Climate change impacts have already affected many CDFW hatcheries, resulting in altered or inconsistent operation schedules, lowered production, and emergency fish evacuations. These climate impacts include increasing water and air temperatures, changes to groundwater availability, low flows and water shortages, increased flood and fire risks, and other second-hand impacts associated with each of these categories (i.e., emerging pathogens and non-infectious diseases, low adult salmon returns, decreased worker safety, etc.).

A total of 21 hatcheries were visited by McMillen to evaluate the existing infrastructure and fish production operations. During these visits, McMillen assessed the existing hatchery infrastructure deficiencies and replacement needs. The assessment was used to aid in determining the potential upgrades for each hatchery that would maintain the existing program production goals for the various species reared at each facility while providing conceptual alternatives for climate resilience. Climate change has had an impact worldwide and will continue to affect CDFW’s statewide fish production operations. Developing technologies and methods to meet fishery conservation and sport fisheries is critical to CDFW’s goal of maintaining hatchery productivity while conserving precious cold-water supplies for native species.

We have based our detailed work plan on achieving the following project objectives stated in the Request for Proposals (RFP). As presented in Sections 2 and 3 of our proposal, we have intentionally comprised our team of experts in all required disciplines with experience in fish husbandry and hatchery engineering and design to successfully meet all CDFW’s project goals.

- **Objective 1:** Review the state of each facility via data collection, review of documents, site visits, and discussions with hatchery personnel. Identify climate change impacts that are likely to negatively impact operations at each hatchery over the next 40 years.
- **Objective 2:** Develop cost effective and programmatically viable alternatives that will maintain current fish propagation goals given climatic impacts in the future.
- **Objective 3:** Assess the risks of each alternative to natural biological systems, environmental conditions, husbandry techniques for fish health and fish safety, and potential impacts to water quality.
- **Objective 4:** Determine the short- and long-term economic costs for the modifications to each hatchery in current year dollars. Account for construction, permitting, design, operational, and maintenance costs within the overall economic analysis. Prioritize the list of alternatives and associated hatcheries based on limited annual hatchery budgets.
- **Objective 5, Phase 2 Work:** Provide complete designs with issued for construction drawings and specifications for projects at as many hatcheries as are feasible. The focus shall be on those hatcheries that are deemed most susceptible to negative climate change impacts identified from the evaluation in the four previous objectives.

1.3 Project Purpose

The purpose of the Project is to determine the CDFW hatcheries and the existing infrastructure conditions that are most susceptible to reduced fish production attributable to climate change and provide a prioritization of the hatcheries for improvements. With input from CDFW, designs for climate change resiliency upgrades will be advanced for as many facilities as is feasible.

1.4 Project Location Description

The Nimbus Hatchery is located approximately 15 miles east of Sacramento, CA and is adjacent to the American River Hatchery (Figure 1-1).

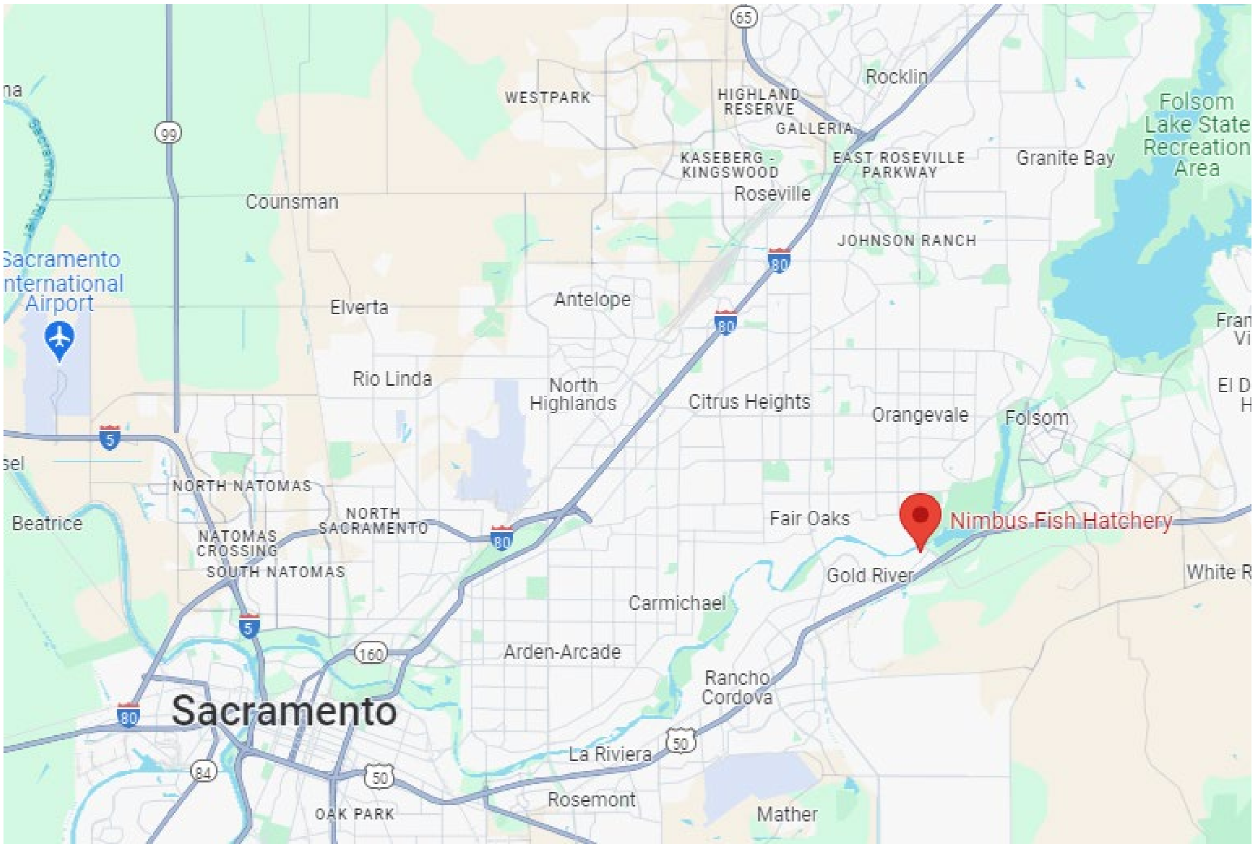


Figure 1-1. Nimbus Hatchery Location Map.

The Nimbus Hatchery was built by the U.S. Bureau of Reclamation (USBR) in 1955 to mitigate lost salmon and steelhead habitat caused by the construction of the Folsom and Nimbus dams. The facility is owned by the USBR and operated by CDFW. The hatchery operates as a flow-through system and receives water from an intake in Lake Natoma, which provides approximately 54 cfs. The hatchery spawns and raises Central Valley fall-run Chinook Salmon (*Oncorhynchus tshawytscha*) and a coastal strain steelhead trout (*O. mykiss*). Mitigation targets for fish production are 4 million Chinook Salmon smolts (~3.5 inches) and 430,000 yearling steelhead (~8.9 inches). The general hatchery facilities are shown in Figure 1-2. More detailed descriptions and photos of the Nimbus Hatchery facilities are described in the Site Visit Report (Appendix A).

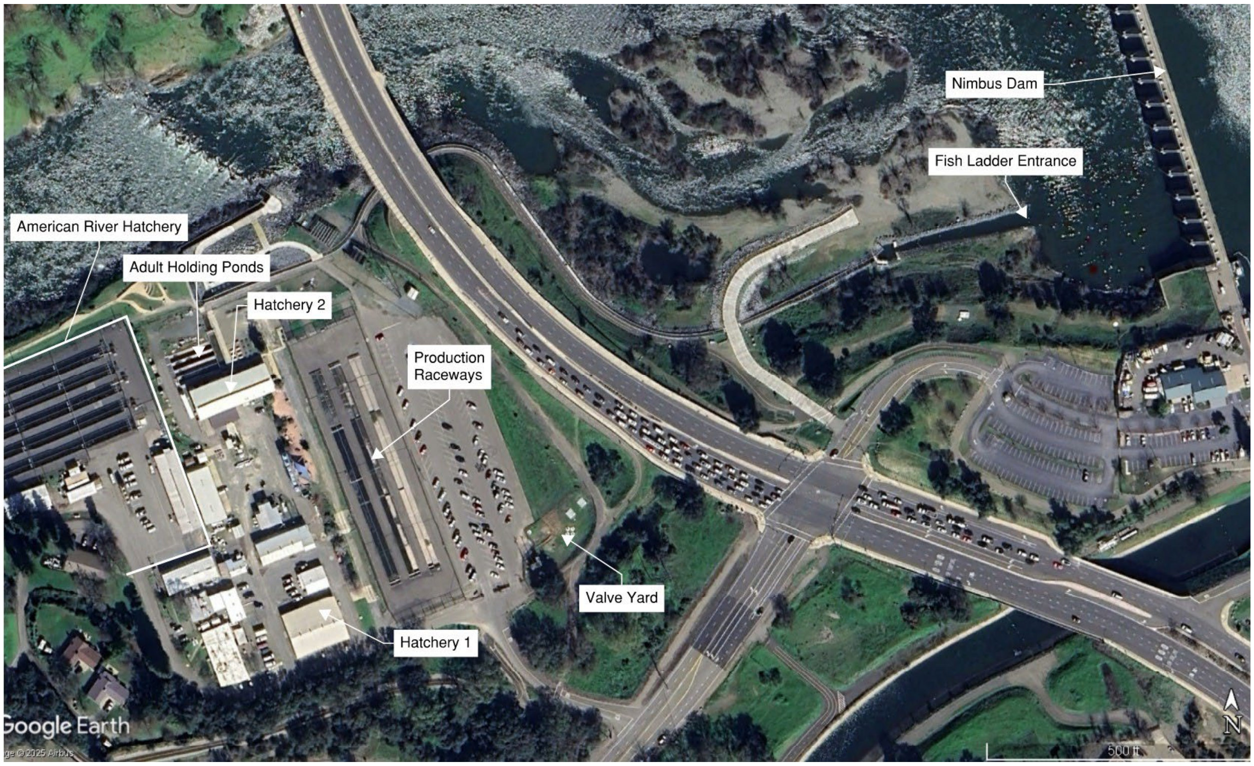


Figure 1-2. Nimbus Hatchery Layout. Google Earth Image Date: 2/18/2022.

2.0 Bioprogram

2.1 Production Goals and Existing Capacity

The Nimbus Hatchery was established to mitigate the loss of salmon and steelhead spawning and rearing habitat after the construction of Nimbus Dam in 1955. Production also supplements commercial and recreational fisheries in the river and ocean. The facility is operated by CDFW under contract with the U.S. Bureau of Reclamation (USBR) and raises fall-run Chinook Salmon and coastal strain steelhead. The Fish and Wildlife Coordination Act report of 1953 requires the USBR to compensate for the loss of approximately 72% of the historic Chinook Salmon habitat and 100% of the historic steelhead habitat in the lower American River; this translates to a restoration goal of 18,823 returning adult Chinook Salmon, and 1,287 returning adult steelhead. The current production goals for the Nimbus Hatchery are shown in Table 2-1. Production is split to show minimum production goals to meet mitigation requirements, and supplemental production to benefit recreational and commercial fisheries or to otherwise enhance the fishery in the wake of severe drought.

Table 2-1. Annual Production Goals at the Nimbus Hatchery.

Species	Minimum Mitigation Requirements	Supplemental Production	Total Production Goal
Fall-Run Chinook Salmon	8 million eggs collected 4 million smolts released (90 to 60 fpp[a], 3.3 to 3.8 inches)	500,000 smolts 2 million fry (post yolk-absorption)	4.5 million smolts 2 million fry
Steelhead Trout	1.2 million eggs collected 430,000 yearlings released (4 fpp, 8.9 inches)	None	430,000 yearlings

[a] Fish per pound (fpp)

The Capacity Biological Program (Capacity Bioprogram) for the facility was developed for the Site Visit Report (Appendix A) and provides the total numbers of fish and biomass that can be produced for all rearing tanks based on tank volume, operational water flows, and size of the fish. The calculations utilize the density and flow indices previously identified for the preliminary bioprograms which address fish biomass (density index) and also encompass water temperature and elevation criteria to ensure oxygen levels appropriately align with production (flow index). The calculations include a 10% safety factor to provide a 90% maximum capacity based on both the density index (DI) and flow index (FI) requirements identified. A summary of the rearing capacities identified in the Capacity Bioprogram is shown in Table 2-2 and Table 2-3. As noted in Table 2-1, the total production goal for Chinook Salmon is 4.5 million smolts, with a production goal of 430,000 Steelhead yearlings.

Table 2-2. Capacity of Chinook Salmon at the Nimbus Hatchery per the Capacity Bioprogram (Appendix A).

Rearing Unit (max. fish size)	Total Capacity (Fish)[a]	Limiting Factor
Deep tanks (200 fpp/2.6 inches)	593,097	Rearing volume
Raceways (60 fpp/3.8 inches)	3,204,505	Water flow

[a] This is an estimate of 90% production capacity to allow for a buffer in circumstances where more flexibility is needed for hatchery operations.

Table 2-3. Capacity of Steelhead at the Nimbus Hatchery per the Capacity Bioprogram (Appendix A).

Rearing Unit (max. fish size)	Total Capacity (Fish)[a]	Limiting Factor
Deep tanks (120 fpp/2.9 inches)	107,339	Rearing volume
Raceways (4 fpp/8.9 inches)	392,169	Water flow

[a] This is an estimate of 90% production capacity to allow for a buffer in circumstances where more flexibility is needed for hatchery operations.

2.2 Bioprogram Summary

The Capacity Bioprogram in the Site Visit Report (Appendix A) demonstrates the total capacity of each rearing area at the Nimbus Hatchery for several stages of fish production. The capacity of each rearing area (-10% to provide an additional safety factor), limited by water flow or available rearing volume, is shown in Table 2-2 and Table 2-3. At first glance, the total capacity for the Nimbus Hatchery falls short of the production goals shown in Table 2-2 and Table 2-3. However, the range of acceptable release sizes for Chinook Salmon, and their 3-month release window allows for flexibility to meet production goals. Steelhead production goals can be met within the designated criteria, though it requires use of over 98% of the facility's raceway rearing capacity leaving little room for operational flexibility. Details about the various rearing areas and infrastructure are discussed in the Site Visit Report.

In this current report, we developed an initial Production Bioprogram (Appendix B) to illustrate the potential maximum production that the facility is capable of while remaining within the limits set by the Capacity Bioprogram.

2.2.1 Criteria

The methods and reasoning used to determine the criteria associated with biological programming for the Nimbus Hatchery can be found in Appendix A. For reference, the established criteria are shown in Table 2-4. To model the production cycle schedule for the Production Bioprogram, survival assumptions are made and included in Table 2-5. This bioprogram also assumes optimal egg development and fish growth given the water temperatures experienced at the facility. Survival rates and information to estimate growth rates were provided by Nimbus Hatchery staff.

The growth rate fluctuates with water temperature but is between 0.5 and 0.7 inches per month.

Table 2-4. Criteria Used for the Production Bioprogram; Discussed in Detail in Appendix A.

Criteria	Value
Density index (DI)	Chinook Salmon – 0.28 Steelhead – 0.17
Flow index (FI)	1.45
Water temperature	55 to over 70°F

Table 2-5. Survival Assumptions Used for the Production Bioprogram.

Species	Assumptions
Chinook Salmon	Egg-to-fry: 50%[a] Fry-to-juvenile (200 fpp): 95% Juvenile-to-outplant (60 fpp): 95%
Steelhead	Egg-to-juvenile (120 fpp): 78.34% Juvenile-to-outplant (5 fpp): 92.48%

[a] Egg collection goals are typically twice as many as are needed for production goals (i.e., plan for 50% survival). This allows the program to capture the genetics of the entire salmon run. Eggs are culled as needed; survival of kept eggs is approximately 85%.

2.2.2 Production Bioprogram

This bioprogram (Appendix B) is meant to view hatchery operations at a high level and does not capture the nuances of specific timing of fish transfers, grading, sorting, or stocking. The model is meant to show an example of how production may occur given the criteria and assumptions outlined in the previous section.

2.2.2.1 Fall-Run Chinook Salmon

Broodstock collection from the fish ladder begins each fall in the first week of November and continues through mid-December. The spawning operations include approximately 13 to 16 spawning events during this period, with a unique egg lot for each event. This includes events used for parental based tagging (PBT) release strategies. The bioprogram follows the initial egg lot's progress through the hatchery. Once later egg lots have developed and are transferred to raceways, they are included in the total rearing population. Growth rates are adjusted based on the timing difference among egg lots to provide relatively uniform development and ensure all egg lots are near the target release size of 60 fpp at the end of May.

The first egg lot hatches and begins feeding at the end of January (approximately 1,500 temperature units post fertilization) at an approximate size of 1,200 fpp (1.4 inches; Table 2-6). The initial group that moves through the deep tanks will begin with approximately 1.06 million first feeding fry. At the end of February, this group will reach approximately 400 fpp (2.0 inches); in March they are expected to be transferred out to the raceways as growth in the deep tanks reduces due to increased densities. This transfer will coincide with fish from later egg lots transferring into the deep tanks. By the end of March, approximately 1.75 million fish will be reared in three raceways at an approximate size of 190 fpp (2.6 inches); marking and tagging operations will begin in late March or early April when the first egg lots reach approximately 120 fpp (3 inches). The remaining fish in the deep tanks will be transferred to the raceways in April, by the end of the month there will be approximately 3.59 million fish at an average size of 100 fpp (3.2 inches); all fish will be marked by the end of April. By the end of May, approximately 3.5 million fish will be stocked out at approximately 60 fpp (3.8 inches).

Table 2-6. End of Month Production Information for the Fall-Run Chinook Salmon Bioprogram Including Realized DI and FI Values.

Production Stage/Month	Tank Type	Tanks Occupied	fpp	Length (in)	Total Fish (#)	Biomass (lbs)	Max. Flow (cfs)	DI	FI
Jan	Deep tanks	68	1,200.0	1.40	1,060,717	883.9	7.6	0.14	0.19
Feb	Deep tanks	68	400.0	2.00	1,000,000	2,500.0	7.6	0.28[a]	0.37
Mar	Raceways	3	190.0	2.60	1,750,000	9,210.5	12.0	0.10	0.66

Production Stage/Month	Tank Type	Tanks Occupied	fpp	Length (in)	Total Fish (#)	Biomass (lbs)	Max. Flow (cfs)	DI	FI
Apr	Raceways	6	100.0	3.20	3,592,105	35,921.1	24.0	0.16	1.04
May	Raceways	6	60.0	3.80	3,500,000	58,333.3	24.0	0.21	1.43

[a] Additional fish reared in the deep tanks would result in exceedance of the DI criteria.

2.2.2.2 Steelhead

Broodstock collection efforts for steelhead begin in mid-December, though ripe adults are not typically present until the last week of December. Broodstock collection lasts until the end of February. There are approximately 10 spawning events per year, each a week apart. This bioprogram follows the earliest egg lot's growth and development schedule. Fish from later egg lots are added to the total population in the raceways after they have completed the early rearing phase. Growth rates are adjusted based on the timing difference among egg lots to provide relatively uniform development and ensure all egg lots are near the target release size of 4 fpp the following January or February.

The first egg lot is expected to hatch in February and be ready for first feeding at approximately 1,800 fpp (1.2 inches) by the end of February (Table 2-7). Fish are reared in deep tanks until approximately 107,500 fish have reached a size of 120 fpp (2.9 inches); the first egg lots should reach this size at the end of May. Approximately 200,000 steelhead will be transferred to the raceways by the end of June, this is coordinated with the final releases of Chinook Salmon. Only three raceways will be used for steelhead at the end of June, while the remaining steelhead egg lots are still in early rearing. By the end of July, approximately 420,000 steelhead are spread among all six raceways and the population has an average size of 36 fpp (4.3 inches). Fish are reared in the raceways until they approach the target release size of 4 fpp (8.9 inches) in February. Approximately 392,000 steelhead are released by the end of February to make space for next year's Chinook Salmon to be transferred into raceways.

Table 2-7. End of Month Production Information for the Steelhead Bioprogram Including Realized DI and FI Values.

Production Stage/Month	Tank Type	Tanks Occupied	fpp	Length (in)	Total Fish (#)	Biomass (lbs)	Max. Flow (cfs)	DI	FI
Feb	Deep Tanks	20	1,800	1.2	137,222	76.2	2.2	0.03	0.06
Mar	Deep Tanks	20	500	1.8	127,315	254.6	2.2	0.07	0.14
Apr	Deep Tanks	20	200	2.4	117,408	587.0	2.2	0.12	0.24

Production Stage/Month	Tank Type	Tanks Occupied	fpp	Length (in)	Total Fish (#)	Biomass (lbs)	Max. Flow (cfs)	DI	FI
May	Deep Tanks	20	120	2.9	107,500	895.8	2.2	0.15	0.31
Jun	Raceways	3	60	3.6	200,000	3,333.3	12.0	0.03	0.17
Jul	Raceways	6	36	4.3	420,071	11,668.6	24.0	0.04	0.25
Aug	Raceways	6	22.5	5.0	416,085	18,492.7	24.0	0.05	0.34
Sep	Raceways	6	15.4	5.7	412,099	26,759.7	24.0	0.07	0.44
Oct	Raceways	6	10.9	6.4	408,113	37,441.6	24.0	0.08	0.54
Nov	Raceways	6	8.3	7.0	404,127	48,690.0	24.0	0.10	0.65
Dec	Raceways	6	6.5	7.6	400,141	61,560.2	24.0	0.11	0.75
Jan	Raceways	6	5.0	8.3	396,155	79,231.0	24.0	0.13	0.89
Feb	Raceways	6	4.0	8.9[a]	392,169	98,042.3	24.0	0.15	1.02

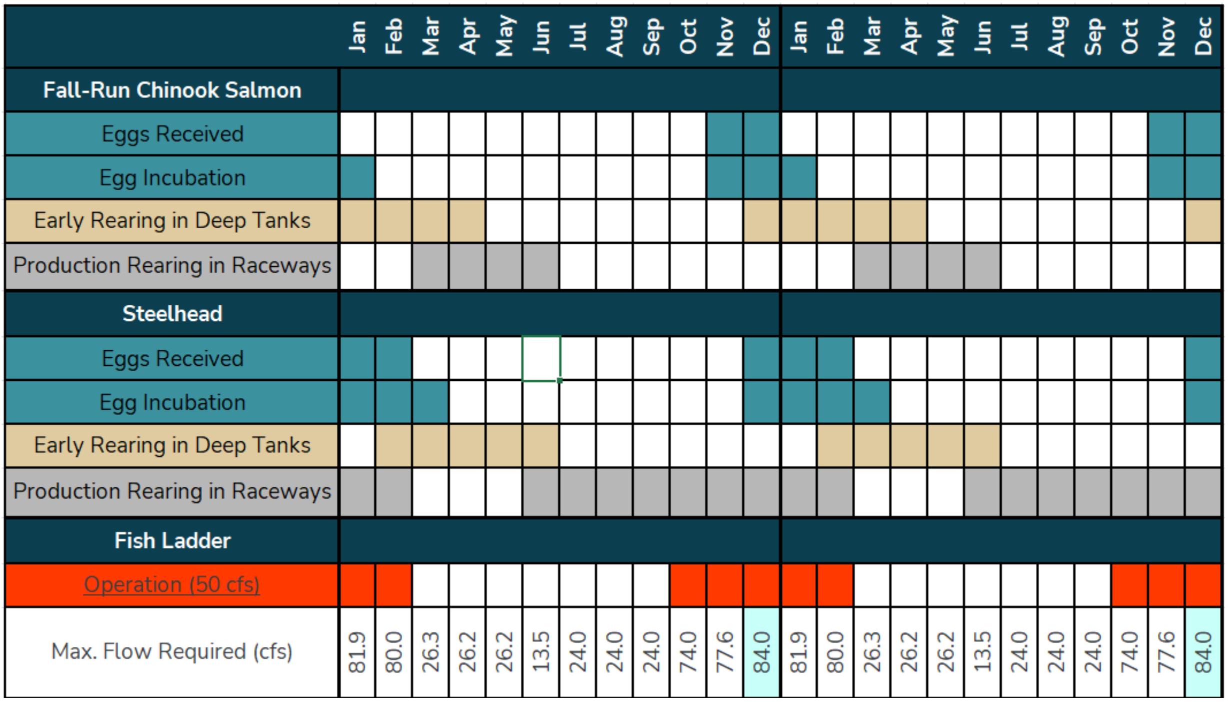
[a] The DI criteria of 0.17 will be exceeded if additional fish of this size are held in the rearing units.

2.2.2.3 Summary

This bioprogram results in approximately 3.23 million fall-run Chinook Salmon released by the end of May at 60 fpp (3.8 inches) and approximately 392,000 steelhead trout released in January or February at 4 fpp (8.9 inches) each year. Hatchery operations involve fish from different egg lots and stages of development, which impacts the average size of fish and subsequently the rearing densities. This high-level bioprogram does not capture weekly differences among egg lots; hatchery operations involve more flexibility to fine tune densities based on developmental stages to exceed production identified in this bioprogram.

Water demand is highest while the fish ladder is operating; the fish ladder requires up to 50 cfs during broodstock collection periods from October to February each year (Figure 2-1). Note that the different colored blocks in Figure 2-1 correspond to the months in which each species (Fall-Run Chinook Salmon and steelhead) is in either the deep tanks or raceways, along with noting are received and incubated.

The water demand for this bioprogram peaks in December at approximately 84 cfs; this coincides with yearling steelhead occupying all raceways and fall-run Chinook Salmon beginning the early rearing phase in deep tanks. Water demand estimates for egg incubation were provided by Nimbus Hatchery staff, while fish rearing water demand was modeled in Table 2-6 and Table 2-7.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Fall-Run Chinook Salmon																								
Eggs Received											■	■											■	■
Egg Incubation	■										■	■	■										■	■
Early Rearing in Deep Tanks	■	■	■	■								■	■	■	■	■								■
Production Rearing in Raceways			■	■	■	■									■	■	■	■						
Steelhead																								
Eggs Received	■	■										■	■	■										■
Egg Incubation	■	■	■									■	■	■	■									■
Early Rearing in Deep Tanks		■	■	■	■	■								■	■	■	■	■						
Production Rearing in Raceways	■	■				■	■	■	■	■	■	■	■	■				■	■	■	■	■	■	■
Fish Ladder																								
Operation (50 cfs)	■	■								■	■	■	■	■								■	■	■
Max. Flow Required (cfs)	81.9	80.0	26.3	26.2	26.2	13.5	24.0	24.0	24.0	74.0	77.6	84.0	81.9	80.0	26.3	26.2	26.2	13.5	24.0	24.0	24.0	74.0	77.6	84.0

Figure 2-1. Production Rearing Schedule Over 2 Years with Peak Water Demand Occurring Annually in December (as highlighted in the Max Flow Required row).

3.0 Climate Evaluation

This section presents projections of air temperature and wildfire risk for the hatchery site.

The Nimbus Hatchery falls within California's Central Valley Project, a complex network of dams, reservoirs, canals, and other water resource facilities. The network is tightly controlled based on the domestic water and power needs of the Sacramento and San Francisco Bay population centers. Due to the complexity of the system and the significant level of influence that the USBR and other water control agencies have on operations and management, effects of future climate change will depend not only on the seasonal hydrologic response of the American River watershed but also on future water demand and especially on management decisions such as user allocations, which cannot be anticipated in this work. For these reasons, CDFW directed NHC to forgo a climate evaluation for this facility during the Central Valley Water Temperature and Flow Control Meeting held on May 30, 2023.

Other sources available that provide insight on the conditions of the Central Valley Project in the context of climate change are reported every five years by the California Department of Water Resources in their California Water Plan Update Future Scenarios Analysis, with 2023 as the most recent update (CDWR, 2023). Additional resources include California Climate Change Assessments, with reports specific to California's Central Valley water system (Schwarz et al., 2018).

3.1 Introduction

In this section, projections of air temperature conditions at the Hatchery site are presented for the next 20 years (2024-2043) and the following 20 years (2044-2063) and will be compared against the reference period (1984-2003). These time horizons are referred to as the near-future period and the mid-century period, respectively. These projections inform the project team of potential needs for adaptive changes/ Projections of air temperature extremes are included, to inform of potentially hazardous working conditions. Projections of wildfire risk are also presented.

3.2 Methodology for Projecting Air Temperature

This study uses future climatic and hydrologic projections based on global climate model (GCM) simulations associated with the data set known as CMIP5, which was part of the fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2014). The projections in this report are based on results from 10 different global climate models under the Representative Concentration Pathway (RCP) RCP4.5 scenario of future greenhouse gas emissions, which represents a future with modest reductions in global emissions compared to current levels.

An ensemble of 10 global climate models (GCMs), listed in Table 3-1, is used for capturing a wide range of plausible climate projections. Since this project's future time horizon is limited to 40 years, the dominant source of uncertainty in climate projections is expected to be the natural variability of the earth's climate (and the variability present in every GCM model run), with a second major source of uncertainty being differences between GCMs. Using this ensemble will simultaneously address both uncertainty sources. The selection of 10 GCMs was based on tests of their ability to accurately simulate California climate, following the study of 35 CMIP5 models (Krantz et al., 2021).

Table 3-1. List of Global Climate Models Used in This Study.

No.	GCM	Research Institution
1	ACCESS-1.0	CSIRO, Australia
2	CanESM2	Canadian Centre for Climate Modelling and Analysis, Canada
3	CCSM4	National Center for Atmospheric Research, United States
4	CESM1-BGC	National Science Foundation, Department of Energy, and National Center for Atmospheric Research, United States
5	CMCC-CMS	Centro Euro Mediterraneo per Cambiamenti Climatici, Italy
6	CNRM-CM5	Centre National de Recherches Météorologiques / Centre Européen de Recherche et Formation Avancées en Calcul Scientifique, France/European Union
7	GFDL-CM3	NOAA Geophysical Fluid Dynamics Laboratory, United States
8	HadGEM2-CC	Met Office Hadley Centre, United Kingdom
9	HadGEM2-ES	Met Office Hadley Centre, United Kingdom
10	MIROC5	Japan Agency for Marine-Earth Science and Technology, Atmosphere and Ocean Research Institute (The University of Tokyo), and National Institute for Environmental Studies, Japan

The methodology used for obtaining projections of air temperature, which is summarized in Figure 3-1, was based on simulations by the 10 selected CMIP5 global climate models (GCMs). The GCM projections were statistically downscaled (using different methodologies) by a consortium of research institutions and made publicly available for all of California at a grid cell spatial resolution of 1/16° x 1/16° (about 5 km x 7 km) (Vano et al., 2020). In this report, the downscaling methodology named “Localized Constructed Analogs” (LOCA) is used. The choice of the LOCA data set was guided by its proven ability to represent extreme values of the downscaled climatic variables (important to this study) and because the hydrologic projections used for other California fish hatchery studies were based on the LOCA-downscaled climate projections. The difference between greenhouse gas emissions scenarios is small for a time horizon of 20 years. Therefore, it is sufficient to use one greenhouse gas emissions scenario in this study, and the moderate scenario RCP4.5 is used.

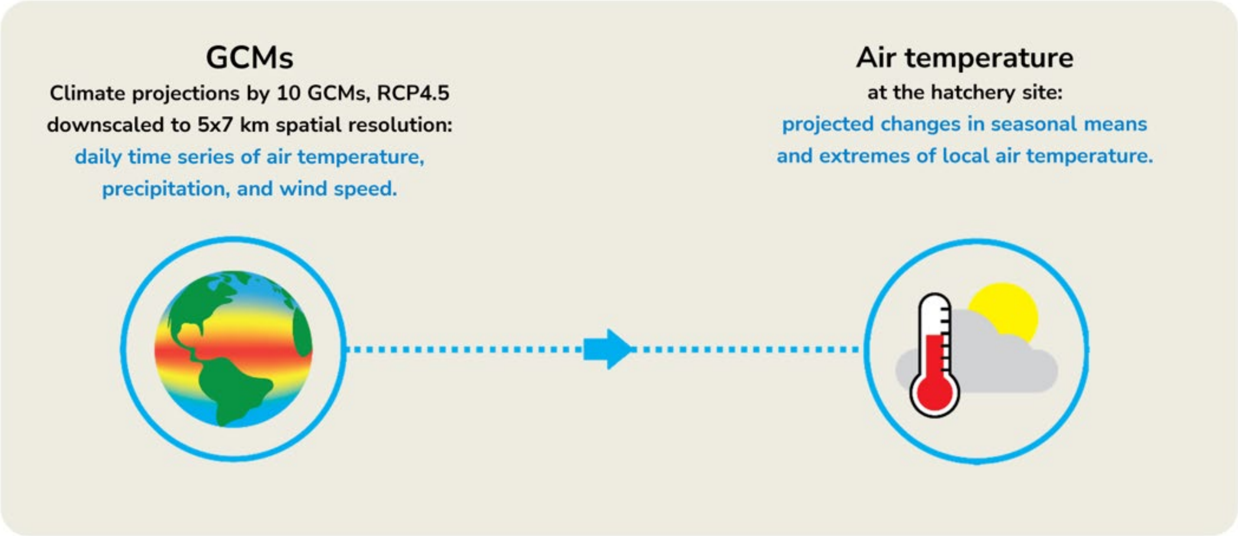


Figure 3-1. Methodology for Obtaining Air Temperature Projections.

3.3 Uncertainty and Limitations

It is important to acknowledge the large and unquantifiable uncertainty associated with these and any climate projections. The projections of air temperature presented here should therefore be considered as plausible representations of the future, given the best current scientific information, and do not represent specific predictions. The actual future realizations of air temperature over this hatchery area will differ from any of the projections considered here, and their differences compared to historical climate may be greater or smaller than the differences in the projections considered.

3.4 Projected Changes in Air Temperature at the Hatchery Site

Figure 3-2 displays the simulated mean daily air temperature (solid lines) and its range from minimum to maximum (shaded areas) for each day of the year, for the near-future time period (red) and the reference period (blue). All data are simulated by the ensemble of 10 GCMs for each time period. Higher peaks of daily temperature are seen for the near future compared to the reference period, while the historical period has lower minima.

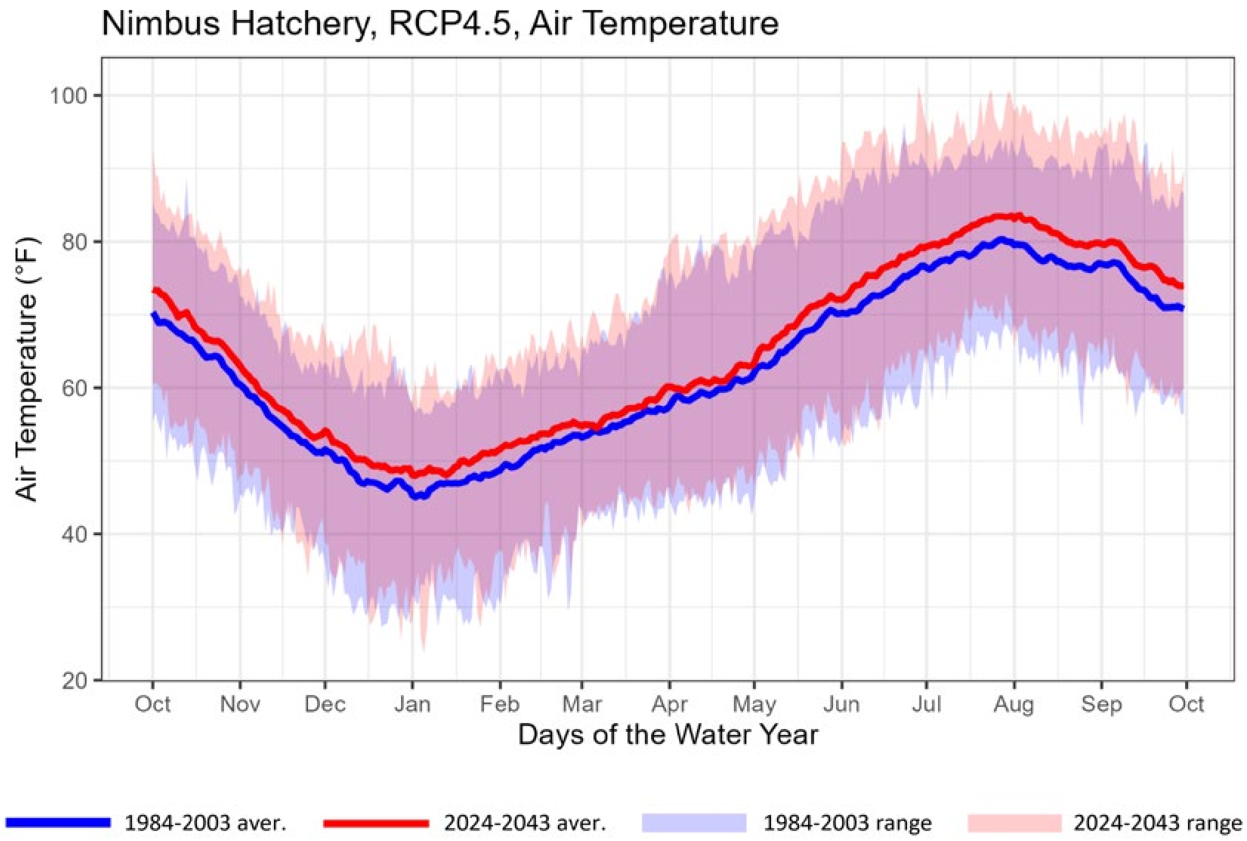


Figure 3-2. Mean Daily Air Temperature and Range for Each Day of the Water Year.

Table 3-2 and Table 3-3 list the projected mean seasonal air temperature for two future time periods, and the temperature change relative to the reference period. All time horizons, including the reference period, are simulated by the ensemble of 10 GCMs. The lowest and highest of the 10 GCM daily projections define the lower and upper limits of the shaded areas in Figure 3-2 and are given in Table 3-2 and Table 3-3.

Table 3-2. Projected GCM 2024-2043 Mean Seasonal Air Temperature at the Hatchery Site (change relative to 1984-2003).

GCM	Annual	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
Ensemble mean	65.7°F (+2.5°F)	51.7°F (+2.4°F)	63.2°F (+1.8°F)	79.8°F (+3.2°F)	68.0°F (+2.7°F)
Lowest	65.3°F (+2.1°F)	50.7°F (+1.4°F)	62.7°F (+1.3°F)	78.6°F (+2.0°F)	66.8°F (+1.5°F)
Highest	66.4°F (+3.2°F)	52.5°F (+3.2°F)	64.1°F (+2.7°F)	81.0°F (+4.4°F)	68.9°F (+3.6°F)

Table 3-3. Projected GCM 2044-2063 Mean Seasonal Air Temperature at the Hatchery Site (change relative to 1984-2003).

GCM	Annual	Winter (DJF)	Spring (MAM)	Summer (JJA)	Fall (SON)
Ensemble mean	66.8°F (+3.6°F)	52.8°F (+3.5°F)	64.3°F (+2.9°F)	81.1°F (+4.5°F)	68.9°F (+3.6°F)
Lowest	66.3°F (+3.1°F)	51.9°F (+2.6°F)	63.7°F (+2.3°F)	79.4°F (+2.8°F)	67.6°F (+2.3°F)
Highest	67.5°F (+4.3°F)	54.0°F (+4.7°F)	65.1°F (+3.7°F)	82.5°F (+5.9°F)	69.9°F (+4.6°F)

Table 3-4 and Table 3-5 list the projected percentiles of highest temperature each day (T_{max}) for two future time periods, relative to the reference period. All time horizons, including the reference period, are simulated by the ensemble of 10 GCMs.

Table 3-4. Projected 2024-2043 Percentiles of Highest Air Temperature in Each Day (T_{max}) at the Hatchery Site (change relative to 1984-2003).

GCM	3rd percentile	25th percentile	50th percentile	75th percentile	97th percentile
Ensemble mean	52.5°F (+2.3°F)	63.8°F (+2.0°F)	77.2°F (+2.1°F)	92.1°F (+3.1°F)	105.2°F (+3.4°F)
Lowest	51.5°F (+1.3°F)	63.3°F (+1.5°F)	76.8°F (+1.7°F)	91.0°F (+2.0°F)	103.6°F (+1.8°F)
Highest	54.4°F (+4.2°F)	64.2°F (+2.4°F)	78.0°F (+2.9°F)	93.1°F (+4.1°F)	107.3°F (+5.5°F)

Table 3-5. Projected 2044-2063 Percentiles of Highest Air Temperature in Each Day (T_{max}) at the Hatchery Site (change relative to 1984-2003).

GCM	3rd percentile	25th percentile	50th percentile	75th percentile	97th percentile
Ensemble mean	54.0°F (+3.8°F)	64.8°F (+3.0°F)	78.3°F (+3.2°F)	93.2°F (+4.2°F)	106.3°F (+4.5°F)

GCM	3rd percentile	25th percentile	50th percentile	75th percentile	97th percentile
Lowest	52.6°F (+2.4°F)	64.1°F (+2.3°F)	77.9°F (+2.8°F)	92.0°F (+3.0°F)	104.5°F (+2.7°F)
Highest	55.8°F (+5.6°F)	65.7°F (+3.9°F)	79.2°F (+4.1°F)	94.5°F (+5.5°F)	107.5°F (+5.7°F)

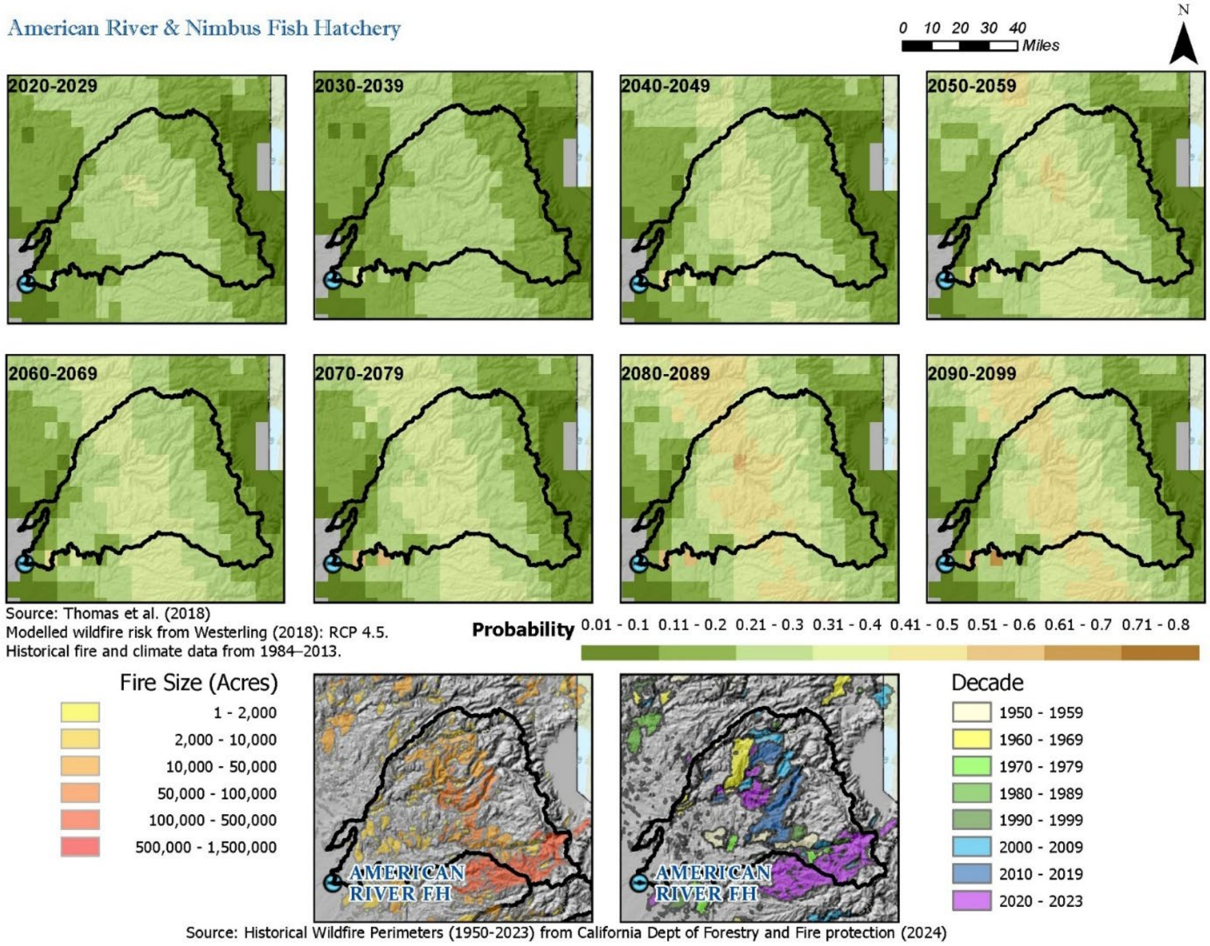
At the hatchery site, mean annual air temperature is projected to rise by 2.5°F in the near future period compared to the reference period (1984-2003), and by an additional 1.1°F in the mid-century period. The season with the most warming is the summer (Table 3-2, Table 3-3, and Figure 3-2) and the highest temperature rises are projected to occur in the hottest days (Table 3-4 and Table 3-5). Days with maximum daytime temperatures representing the 75th percentile (i.e., the upper quartile of temperatures) are projected to warm by 3.4°F in the next 20 years, relative to the reference period. The 97th percentile of the daytime maximum temperature is projected to rise by even more, 4.5°F, reaching 106.3°F. These projected temperatures represent potentially hazardous outdoor working conditions at the hatchery.

3.5 Fire Risk

Historical wildfires have been documented within the watershed perimeter, and less frequently in the local vicinity of the hatchery, as mapped in Figure 3-3. Most of the watershed area has not burned within the past century and therefore has relatively large amounts of fuel stores. While smaller, more frequent fires are more common in the watershed, large wildfires are possible and have occurred in the upper basin, including the 2021 Caldor Fire (Figure 3-3). Landcover in the basin consists primarily of evergreen forest with some grassland, with anticipated fuel recovery rates ranging from 2 to 5 years in grasslands to more than 10 years in the uplands (depending on the type).

Expressing wildfire risk as a percent chance of occurring at least once in a decade (Westerling, 2018), the projected wildfire risk at the hatchery site is approximately 6% through mid-century (Figure 3-3). Across the uplands, the projected fire risk is higher, with local zones increasing to 50% towards the end of this century.

The primary risks to the hatchery operations include infrastructure impacts from local fires, as well as reservoir impacts from fires in the upper basin. Because the hatchery relies on intake from Nimbus Dam, the hatchery is shielded from most flooding and debris that can impact hatcheries along running rivers, except for catastrophic dam failures. Wildfires can impact reservoirs by increasing runoff and turbidity along burn scars. Turbidity was listed as an existing maintenance concern, with dredging required around pipes. Watersheds are most sensitive to flooding and suspended sediment impacts in the first five to ten years after the fire, or the time it takes for new vegetation to mature. The largest risks to the hatchery are therefore increased turbidity following wildfires in the basin, as well as localized fire-related infrastructure hazards to the hatchery itself.



Source: Thomas et al. (2018)
Modelled wildfire risk from Westerling (2018): RCP 4.5.
Historical fire and climate data from 1984–2013.

Source: Historical Wildfire Perimeters (1950-2023) from California Dept of Forestry and Fire protection (2024)

Figure 3-3. Wildfire Risk as Probability of Future Occurrence and Known Historical Fire.

3.6 Conclusions

The climate change evaluation for the Hatchery location was restricted to projections of air temperature and wildfire risk, given instructions by CDFW that streamflow or water temperature evaluations were not requested for this hatchery.

The projected increases in seasonal means and extremes are among the highest of all California hatcheries studied. Mean annual air temperature is projected to rise by 2.5°F in the next 20 years (2024-2043) and by an additional 1.1°F in the mid-century period (2044-2063), compared to the reference period (1984-2003). The summer will experience the most warming, and the largest temperature increases are projected to occur on the hottest days.

The distribution of daily air temperatures will change, and the upper end of this distribution is of most interest. Therefore, we looked at changes in the 75th and 97th percentiles of the daily temperature distribution and found that the 75th percentile will increase by 3.1°F, and the 97th percentile will increase by 3.4°F in the next 20 years, relative to the reference period.

According to gridded air temperatures for the reference period (1984-2003), the 75th and 97th percentiles of peak daytime temperature (i.e., the temperature at the hottest time of day) were 89.0°F and 101.8°F. For the near-future period (2024-2043), these percentiles are projected to rise to 92.1°F and 105.2°F, respectively. Such an increase in the peak air daytime temperature requires adaptation measures for the protection of hatchery workers against heat stroke and other health effects of heat exposure. Roads and roofs may also need to be replaced using more heat-resistant and reflective materials.

The hatchery is at moderate risk of wildfires. The projected chance of at least one wildfire occurring in a 10-year period at the hatchery site is estimated as 6% through mid-century. Most of the watershed has not burned in over a decade, meaning that fuel stores are relatively large in a watershed prone to wildfires. Post-fire conditions also pose risks to the hatchery, including scar-induced flooding, turbidity, and debris.

4.0 Existing Infrastructure Deficiencies

While the Nimbus Hatchery is an operational facility, multiple deficiencies were identified during the site visit and described in Section 4 of the Site Visit Report (Appendix A). Section 5.4 of the Site Visit Report identified potential technologies and solutions available to address specific deficiencies that would allow the hatchery to meet production goals and provide protection against climate change. The main areas of concern for the hatchery included a water supply system in a state of general disrepair with leaking structures and broken valving, high turbidity water supply during wintertime, insufficient rearing space for desired production flexibility, and a raceway system in need of major repairs. Biosecurity deficiencies and potential solutions for addressing these concerns were identified in Sections 3.0 and 3.2 of the Site Visit Report, respectively. The details of these deficiencies are further expanded upon in Sections 4.1 and 4.2.

4.1 Water Process Infrastructure

4.1.1 Lack of Water Filtration

There have been recent improvements to the water piping and conveyance system in the valve yard. Prior to these improvements, the terminal structure would regularly overflow and flood the adjacent area. A faulty gate and automatic programmer have been replaced; they now work in tandem to automatically regulate the water level in the terminal structure independent of the water elevation in Lake Natoma. There may still be issues associated with old and dated valving and piping, but they are not currently affecting hatchery operations.

Staff have noticed increases in turbidity during the winter, which can negatively impact fish welfare and foul downstream equipment. The USBR does not regularly maintain the sediment buildup near the intake pipe in Lake Natoma. Any disturbance in the area can result in increased debris flowing into the hatchery.

4.1.2 Chilled Water Capacity

California’s Central Valley is expected to experience increasing air and water temperatures into the future (CDWR, 2023 and Schwarz et al., 2018). Dangerously high water temperatures at the Nimbus Hatchery have already negatively impacted hatchery operations and the health of the fish populations the facility is helping to preserve. In response to elevated water temperatures, the facility has procured individual tank-chilling units to maintain water temperatures for incubating Chinook Salmon eggs. These chillers are necessary during the early part of the spawning run in November, until water temperatures in Lake Natoma fall below 56°F. It is expected that water temperatures will continue to increase in the future, requiring chilled water for longer periods. The current chilling units work as intended but are not designed for long-term use.

Additionally, increased water temperatures have required Nimbus Hatchery staff to evacuate or release fish from the hatchery earlier than desired. Release sizes are chosen to give fish the greatest chance at survival. Early releases can affect survival, which in turn can impact the adult returns to Nimbus Hatchery in the following years. Evacuating fish to be held at other hatcheries also impacts their success once released. In 2021, water temperatures were projected to exceed 70°F in June and CDFW made the decision to evacuate steelhead from Nimbus to the Mokelumne Hatchery. The steelhead were returned to Nimbus in October 2021, but there are now concerns that Nimbus steelhead may stray to the Mokelumne River and become embedded with the natural spawning Central Valley steelhead population or Mokelumne Hatchery's Central Valley steelhead broodstock population. If the frequency of evacuations increases, it could drastically affect the returns at multiple hatcheries and impact population genetics well into the future. The strategy of evacuating fish to other watersheds where space and cold water is available is not a sustainable approach for the Nimbus Hatchery or the rest of CDFW's anadromous hatcheries. In the future, water will need to be chilled to acceptable temperatures for fish (assuming Nimbus Hatchery will continue to raise salmonids in conjunction with increasing water temperatures).

4.1.3 Low Dissolved Oxygen

According to CDFW hatchery staff, the American River and Nimbus Hatcheries have experienced seasonally low DO concentrations in incoming water supply, between July and November. While the USBR can bypass water from the Folsom Powerhouse to increase DO levels, this draws from a cold-water supply that must be reserved for October when it's needed for adult holding and Nimbus fall-run Chinook spawning operations.

4.2 Rearing Infrastructure

4.2.1 Hatchery Building 1

Hatchery Building 1 was mentioned previously when discussing the lack of chilled water capacity for the facility. Water quality could be increased for this building through the addition of ultra-violet (UV) disinfection. The Nimbus Hatchery possesses the equipment capable of treating the total flows for this building, but the filtration and UV disinfection equipment is uninstalled. Funding was available to purchase drum filters and UV disinfection equipment, but not for the installation which would have cost approximately $2 million six years ago. This equipment has been stored indoors and remains ready for installation, pending an inspection of components. Both established and emerging pathogens are impacted by climate change, and they could easily become more significant problems for the Nimbus Hatchery in the future.

4.2.2 Hatchery Building 2

There is limited rearing space for early rearing of steelhead in available deep tanks, identified in the site visit report (Appendix A). Additionally, a small expansion outside of the building, in the “green room,” required an additional booster pump to convey water, possibly due to the installation of drum filters and UV disinfection system that altered the hydraulic head of the water supply. There should be sufficient head pressure in the system to convey water effectively to all rearing units with an appropriate design, decreasing energy costs associated with extra pumping. A redesign of the early rearing layout for Hatchery Building 2 could also incorporate more tanks to alleviate densities and allow fish to be held indoors for longer.

4.2.3 Raceways

There are six 400-foot-long raceways labelled A through F series. There are significant structural issues with the raceways that make it unsafe for staff to use equipment near them, such as feed carts and marking trailers. Limiting access to usable equipment makes operations difficult and time-consuming. The D- and E-series raceways have significant leakage. In the weeks leading up to McMillen’s site visit, the E-series had large enough leaks that 2-inch fish were escaping from the raceways and onto the adjacent asphalt. The hole was emergency-patched, but shortly after the patch was installed, a sinkhole formed in the nearby asphalt, indicating significant geotechnical issues.

Other raceway series have leaking at expansion joints, and possibly through the stanchion slots in the concrete floor. An emergency contract was executed in 2023, and repairs of leaking expansion joints were completed in late August. The presence of sinkholes and severe cracking in the asphalt around the raceways indicates that the leakage is significant enough to move finer subgrade materials and destabilize the asphalt’s subgrade. The loss of subgrade stability then causes raceway walls to settle or rotate, further destabilizing the area. Aside from the leaking, the condition of the concrete is poor in all raceway series. Continued use without rehabilitation will result in stripping aggregate from the walls and make a rougher, more harmful environment for fish.

5.0 Alternative Selected

5.1 Alternative Description

During the site visit and through meetings with hatchery staff, several deficiencies were identified that currently limit the hatchery's ability to meet fish production goals. These deficiencies have been summarized in Section 4.0 of this report. Appendix E – Alternatives Development Technical Memorandum (TM) provides a discussion of alternative technologies that may be used to address the existing deficiencies and potentially expand production, improve biosecurity, and increase operational efficiencies. The following section presents a summary of the preferred alternative that would best utilize the alternative technologies to respond to the existing deficiencies, maximize fish production, and respond to the climate change projections described in Section 3.0. The conceptual layout of the alternative described below is shown in Appendix C.

5.1.1 Intake System Upgrades

5.1.1.1 Intake Structure Investigation

To maintain the existing intake structures in the reservoir, an investigation and cleaning or dredging of the intakes in the reservoir is proposed. Dive teams were typically used to clean out this area in the past, but this preventative maintenance and assessment has not been performed in recent years. The status of debris, silt, or sediment accumulating near the intake pipes is unknown. To ensure that all infrastructure will remain operational for the next 30 years, a more thorough investigation of the intakes is necessary and may require manual cleaning to remove sediment.

5.1.1.2 42-Inch Intake Screening

An automatic traveling screen is proposed for the older 42-inch intake pipe to complete the redundancy of having multiple intake sources. The new 60-inch intake pipe is fitted with a traveling screen to reduce debris entering the hatchery. The entrance to the old 42-inch intake pipe used to be manually cleaned by a dive team, but this preventative maintenance does not occur now that the new 60-inch intake is regularly used. Adding a traveling screen would allow CDFW to use the old intake system without concern for introducing debris into the hatchery. This would provide flexibility to maintain the infrastructure associated with the 60-inch intake in the reservoir and valve yard, while maintaining a water supply with reduced debris loads.

Improving the 42-inch intake also provides operational flexibility. Improved head conditions may be realized by setting flows thru the valve yard such that Nimbus would be fed from the 60-inch intake and the American River Trout Hatchery would be fed from the 42-inch intake. For this reason, the cost of the 42-inch automatic traveling screen is currently shown within the American River Hatchery cost estimate; this could be modified to show the costs split between the two facilities if desired.

5.1.1.3 Valve Yard Improvements

Valving and automated level sensors in the terminal structure were recently repaired by the USBR. However, there are still issues in the valve yard associated with American River Trout Hatchery's (ARTH) water supply. For more information, please review the American River Trout Hatchery's Climate Resiliency Report. The proposed improvements are discussed in Section 5.1.1. The proposed improvements for the ARTH's water supply infrastructure would require cooperation with the USBR and Nimbus Hatchery to maintain the necessary water supply for fish production. However, the proposed improvement would allow for the independent operation of each hatchery as they would be supplied from different water lines (60 inches for Nimbus and 42 inches for ARTH). Valving replacement will happen at the same time for both facilities; see FIG 3 (Appendix C) for a list of recommended valves to be replaced.

5.1.2 Replace Raceways with Circular PRAS Tanks

The preferred alternative is to replace the existing raceways with circular PRAS tanks covered with solid roof structures and enclosed in fencing and predator exclusion netting. A public access platform is provided at the north end of the PRAS systems to allow viewing down into the circular tanks.

Each PRAS module will contain equipment to recondition and recirculate process water and would include a sump, pumps, mechanical chiller, filtration, UV disinfection, and oxygenation to provide optimal rearing conditions. Each PRAS module will include eight (8) 20-foot-diameter tanks with wall heights of 7 feet and water depths of 6 feet with a rearing volume of 1,885 ft^3. Construction of the PRAS would be contingent upon further geotechnical investigation and subgrade preparation in the current raceway area. If investigations show the area is not suitable for this development, other areas would be considered for construction.

Required flows for each module are based on a hydraulic residence time (HRT) of 45 minutes, based on recommendations for large tanks (Timmons et al., 2018). A process flow rate of 325 gallons per minute (gpm) is required for each tank, or 2,600 gpm (5.8 cfs) for a module. It is recommended that CDFW begin operations with a 50% recirculation rate until staff familiarize themselves with the system and equipment; the recirculation rate may be operated up to 75%

without requiring a biofilter to process nitrogen accumulation. At a 50% recirculation, the fresh make-up water requirement would be 1,300 gpm (2.9 cfs) for each module. At a 75% recirculation rate, the fresh make-up water requirement would be 650 gpm (1.5 cfs) for each module. The PRAS equipment would be sized to recirculate and recondition a flow rate of 1,950 gpm (4.3 cfs).

Ultimately, the preferred alternatives are to build five (5) new identical PRAS modules, or 40 total tanks. This provides enough tanks that Chinook Salmon and steelhead would not be mixed in the same module. In May, all modules would be occupied by Chinook Salmon but by February all modules would be occupied by steelhead. Timing of fish releases allows for opportunities to depopulate and clean specific tanks and recirculation equipment as needed. This number of tanks is sufficient to hold the fish populations modeled in Section 2.2.2 at a DI of less than 0.25. Advanced design phases will account for additional considerations to determine final tank sizing requirements.

The total make-up flow requirement, while operating at a 75% recirculation rate, would be 3,250 gpm (7.2 cfs); while operating at a 50% recirculation the make-up flow requirement would be 6,500 gpm (14.5 cfs). This significantly reduces the amount of water that must be chilled to maintain optimal rearing temperatures for these anadromous species.

Chilling would be included for the five new PRAS modules and would consist of five (5) 200-ton chillers. The chillers are sized to cool the make-up water by 7-degrees Fahrenheit (°F) when operating at 75% reuse and by 3.5°F when operating at 50% recycle.

Advanced designs will include a closer investigation into the potential for volitional releases to a larger tank or basin, from which fish can be crowded and pumped into transport trucks using the Nimbus Hatchery's current procedures. Examples of volitional release systems from circular tanks are rare. One basic option is to remove the side box drain screen and divert the discharge to the desired receiving water. However, not all fish will choose this release route, ultimately requiring at least some seining and harvest of fish from the tanks with more traditional methods.

5.1.3 Hatchery Building 1 Renovations

The selected alternative for Hatchery Building 1 is to add chilling capabilities, filters and gas control column for early rearing. This building uses a maximum flow rate of approximately 8.1 cfs when all available tanks are operating at once. Reuse systems for early rearing are not desirable because of the high feeding rates and small feed sizes that can often clog, foul, or otherwise affect the efficiency and condition of recirculation equipment. Simple pump back systems in early rearing tanks are used at some facilities with reasonable success, but recirculation rates are typically low and water treatment equipment is limited by available space. The intent is for the proposed upgrades to accommodate future climate impacts and eliminate the need and added complexity of pump back systems for individual tanks.

It is anticipated that eggs would be transferred to matrix boxes in Hatchery Building 1 immediately prior to hatch, this would occur in the first part of December at the earliest. Based on typical water temperature trends of the American River near the facility shown in Figure 5-1, temperatures may be low enough for egg incubation at these periods. However, climate impacts for this facility are expected to worsen in the next 30+ years. As a worst-case scenario, we assume that water temperatures may remain as high as 63°F when fish are ready to hatch. To maintain optimal rearing conditions, water would be chilled to 56°F for a temperature differential of 7°F.

Not all tanks will require chilling initially, as full capacity of this building is not reached until February according to hatchery staff. For this report, it is assumed that a maximum of 2.5 cfs is required to be chilled to a temperature differential of 7°F. This would require approximately 400 tons of chilling capacity to account for efficiency loss and safety factors. The chilling system would be designed to allow staff to control chilled water flow to individual tanks. The flexibility of control would ensure that some tanks could support hatching fish at optimal water temperatures while others could be supplied with slightly warmer water for fingerlings from earlier egg collection dates. This avoids chilling the entire hatchery's water supply and provides staff with the flexibility to ensure all cohorts are provided optimal rearing conditions.

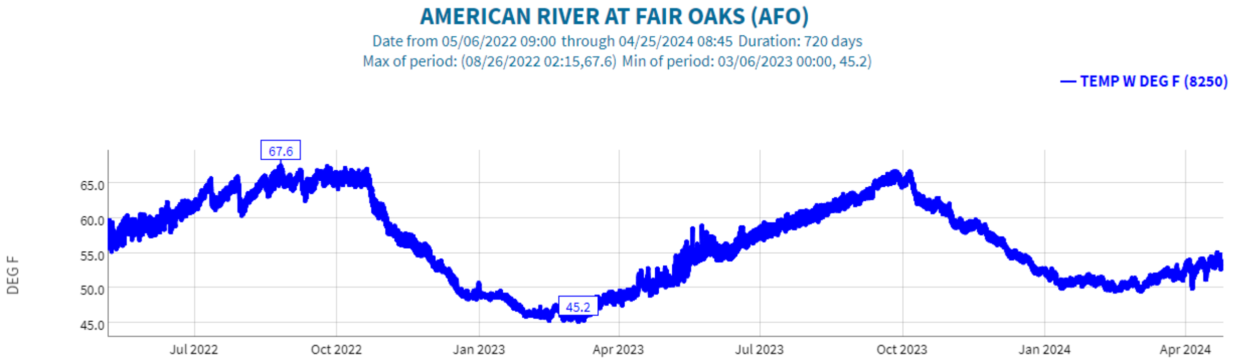


Figure 5-1. American River Water Temperature Records from May 2022 to April 2024 from the California Data Exchange Center (CDEC) AFO Station.

Additionally, the existing UV disinfection equipment for the building will be assessed to determine if it is still economical to install. The condition of equipment must be acceptable and capable of providing the required disinfection dose; it must also operate efficiently. New UV disinfection systems are likely to provide a more cost-effective solution in the long term. The

USBR is responsible for all energy-associated costs with hatchery operations; their input would be sought while making the decision on existing or new UV disinfection equipment.

In addition to adding UV disinfection the Hatch 1 water supply will have valving that will allow the flow to be diverted into a side stream and pumped through pressurized sand filters to remove the fine sediment that Hatchery staff has found making its way into the existing systems. There will be four sand filters with one being additional to make up the lost capacity when one of the filters needs to perform a flushing cycle. After the sand filters, the water will run through a gas control column that will give the hatchery staff the ability to add additional oxygen to the water if the oxygen levels are too low. The water will then run through a buffer tank that is connected to the chiller to accommodate those peak temperatures as mentioned above. From the buffer tank the water will be run through the UV filter and either deposited back into the existing hatchery supply lines or split into additional lines that will provide the ability for the chilled water to be sent directly to individual tanks. See Figure 1.2 in Appendix C for more detail.

5.1.4 Hatchery Building 2 Renovation

The preferred improvement for Hatchery Building 2 is to install a water reuse system and mechanical chilling unit for egg incubation. The goal is to reduce water temperatures economically by decreasing the amount of water that requires chilling. The Nimbus Hatchery is already incubating eggs in a recirculating environment in Hatchery Building 1. The preferred alternative would provide a permanent, less complex system for Hatchery Building 2, eliminating the need for egg incubation in Hatchery Building 1.

Water temperatures are typically highest in September and October (Figure 5-1), immediately prior to egg collection beginning. Climate impacts are expected to worsen and are likely to result in critically high water temperatures (>70°F) experienced more often for more prolonged periods that may extend into the egg collection season. This will likely impact adult salmon and steelhead behavior in the American River; those changes are outside the scope of this report and as such, we will assume that egg collection does not deviate significantly from the timing described in Section 2.0. For this alternative analysis, it is assumed that 72°F may be experienced during the egg incubation season as a worst-case scenario. To design for operations 30+ years into the future it is assumed that all the incubating units would require chilling at the same time. Heath stack recirculating systems are already in use at other CDFW hatcheries (Silverado Fisheries Base), and Nimbus has already developed preliminary reuse systems for upwelling jars. If the Nimbus Hatchery is selected for advanced design, existing incubation reuse systems would be closely evaluated, and McMillen would suggest improvements to incorporate similar infrastructure into Hatchery Building 2.

All vertical stacks and hatching jars in Hatchery Building 2 require approximately 2.6 cfs of flow for concurrent operation. Improvements would target a water reuse rate of approximately 80% for egg incubation and would include aeration/degassing (by spray bars at the top of each stack, similar to other CDFW incubation reuse systems) and UV disinfection as minimum water treatments. The maximum proposed make-up flow would be 0.5 cfs requiring chilling to 56°F; it is assumed that ambient heating of the system would be negligible as it would occur in a conditioned space. A total of 12 incubation recirculation modules are proposed, each serving three full Heath stacks. Assuming a maximum critical temperature of 72°F, the temperature differential would be 16°F which would require a 200-ton chilling system.

5.2 Pros/Cons of Selected Alternative

Table 5-1 provides a high-level summary of the pros and cons for the selected alternative for the Nimbus Hatchery.

Table 5-1. Pros/Cons of Selected Alternative – Nimbus Hatchery.

Description	Pros	Cons
Investigate and clean or dredge the area in front of the intake structure.	• Improves water supply redundancy. • Identifies other necessary improvements preemptively.	• This is not a permanent solution, as the area will fill in again with sediment and debris over time.
Add an automatic traveling screen for the 42-inch supply pipe.	• Reduces sediment in water supply. • Improves water supply redundancy. • Has operational flexibility to separate water supply from ARTH.	• Increases capital cost. • Requires regular inspection and maintenance.

Description	Pros	Cons
Replace raceways with circular PRAS tanks, includes a solid roof structure and chain-link fencing.	• Increases efficiency for water use. • Provides protection against predators and increases biosecurity. • Maintains optimal rearing conditions during environmental changes, which avoids fish evacuations.	• Increases energy demand and operating costs significantly. • Increases costs significantly due to construction. • Disrupts production time during construction. • May need multiple generators to provide power to all proposed equipment. • Requires staff training because of the more complex rearing systems.
Add chilling capabilities, filters and gas control column for early rearing for Hatchery Building 1.	• Provides optimal egg incubation conditions. • Improves work-flow efficiency for spawning operations, which does not require egg transfers to a separate building. • Includes a bypass, so it can be used only when needed.	• Increases operating costs.
Install a water reuse system with UV disinfection and mechanical chilling unit for egg incubation for Hatchery Building 2.	• Provides optimal early rearing conditions. • Capitalizes on existing disinfection equipment.	• Increases operating costs.

5.3 Alternatives for Short-Term Improvements

In the event that funding is not available to construct the preferred alternative, the following short-term improvements are recommended for continued hatchery operation.

5.3.1 Raceway Improvements

5.3.1.1 Concrete Refurbishment for Raceways

The concrete in the raceways is showing signs of aging after 40 years of service. The underlying aggregate in the floor and walls of the raceways is exposed due to wear which creates an abrasive surface that can be harmful to fish as well as a surface that promotes algae growth. The rough aggregate is difficult for hatchery staff to clean efficiently. Adding a skim coating to the concrete can help alleviate the present issues and reduce the rate at which the concrete surface deteriorates. Over the skim coat, additional products can be applied such as an epoxy-based paint resulting in a smooth surface further protecting the raceway and improving overall tank hygiene as excess feed and fish waste slide more easily toward the tail end of the raceway. Raceway coatings are typically epoxy, polyurethane, or mortar based, but they all serve the same general purpose. Prior to coating the raceways, they must be emptied, cleaned, and completely dried. Additionally, any large cracks or significant damage in the existing concrete will need to be repaired prior to coating. After applying, the coating will need to cure which can take anywhere from 1-14 days depending on the manufacturer's instructions and base component of the coat. Depending on factors such as weather and sun exposure, raceway coatings can last anywhere from 5-15 years. Applying a coat to the concrete creates a surface which is easier to clean, does not promote algae growth, and reduces sun and water exposure to the aging concrete underneath.

5.3.1.2 Add a Roof Structure to the Raceways

Covering the raceways with a roof eliminates direct sunlight and reduces the rate at which the water in the raceways warms, provides protection from avian predation, reduces risk of sunburn on the fish, and allows for a structure that is more easily enclosed to reduce predation. A photovoltaic system (solar panels) can also be incorporated above the shade structure to offset some of the power demands associated with new hatchery equipment.

5.3.2 Upgrade Existing Raceways with PRAS

A recommended short-term improvement is to install PRAS equipment for the raceways to allow for more efficient use of chilled water. Each pair of raceways would be designed as a single module, with shared recirculated water, for a total of three modules. Each pair of raceways would be outfitted with PRAS equipment, to include filtration, UV disinfection, oxygenation, and most importantly, mechanical chillers. Use of the raceway PRAS would likely be required in the late summer and fall when water temperatures can exceed the threshold for safe culture conditions. This would allow the facility to continue operation while reducing the risk of fish evacuations. Fish evacuations are detrimental to the fish that require transfer but can also increase the rate of straying in subsequent brood years which directly affect wild populations.

Each raceway receives a maximum of 4 cfs of water flow and each pair receives up to 8 cfs total. The PRAS equipment would be designed to recirculate and recondition up to 75% of the water flow, or 6 cfs per module. The chilling equipment would treat the fresh make-up water, 2 cfs in this case, to reduce the temperature of incoming water by 10°F to account for periods when the source water temperature exceeds 70°F. As part of the PRAS upgrades to the raceways, concrete surfaces would be repaired and any leaks, broken screen slots, or other damage would be addressed.

5.3.3 Partial Raceway Replacement

The difficulty in completing demolition of existing raceways and constructing additional raceways poses a risk of temporarily lost salmon production at the Nimbus Hatchery. To address these concerns while continuing to make progress on the facility’s climate resiliency, replacing the two raceways in the worst condition is proposed as a short-term improvement. The raceways would be replaced with a PRAS that has circular tanks with the same specifications as those proposed in Section 5.1.2.

The two raceways in the worst condition, Raceways C and D, would still be made available for use during the construction of the new PRAS. The new PRAS would consist of 16 tanks organized into two modules of the same configuration as the proposed improvements. Chilling would be included for the two new PRAS modules and would consist of two 200-ton chillers. The chillers are sized to cool the make-up water by 7° F when operating at 75% PRAS and by 3.5° F when operating at 50% PRAS.

5.3.4 Skim and Epoxy Coating of Raceways

A mortar skim coat is proposed to repair the concrete where pitting and exposed aggregate are present. This would be performed prior to using an epoxy coat, or similar product, to seal the concrete for extended protection. This type of resurfacing maintenance will be required periodically (every 10 to 15 years) to maintain the current raceway operations for the next several decades. Resurfacing the concrete will provide a smoother rearing environment for fish and make it easier for staff to maintain a clean rearing environment.

5.4 Natural Environment Impacts

The proposed upgrades to the Nimbus Fish Hatchery should have negligible impacts on the natural resources in the surrounding area. All improvements would occur within currently developed areas, avoiding requirements for additional environmental or cultural permits not identified in Section 7.0. An exception may occur if any existing structures fall under the jurisdiction of California’s Office of Historic Preservation (OHP).

5.4.1 Fire and Flood Risk

The recommended changes to the Nimbus Fish Hatchery will change the existing infrastructure and the number of rigid structures onsite. This will increase the size of defensible areas that staff must maintain to protect infrastructure against potential fire danger. Future fire risk was not evaluated for this hatchery, but the urban setting suggests that wildfires would be relatively rare. However, the added complexity and pieces of equipment required to operate PRASs present more potential failure points if a fire were to encroach on the hatchery grounds. If fire risk increases due to the proximity of an active fire, special care should be taken to ensure the oxygen generation and/or distribution system is protected and free from leaks.

The Nimbus and American River Hatcheries were not included in the climate change evaluation per CDFW direction since the reservoirs along the American River are heavily managed and do not represent a natural system. Management of the water system will have a more direct impact on the conditions of the hatcheries' water supply relative to climate change. The Nimbus Hatchery will continue to be at some level of risk of flooding in the future given their proximity to the American River. The recommended changes will slightly increase the total impervious surface of the site, this will be addressed with an improved stormwater drain plan throughout the facility. Additionally, upgrading the intake system, replacing valves and piping will provide the hatchery with better flow control into the facility. The hatchery staff will be able to manage flow and prevent flooding associated with the intake structure.

5.4.2 Effluent Discharge

The recommended changes to the hatchery do not include an overall increase in production goals at the Nimbus Hatchery. This will ensure there will be no change to the current NPDES permit requirements. However, the recommended alternatives will result in a smaller, more concentrated waste stream in the effluent because of the recirculating flow technology. The existing effluent ponds are oversized for the production that occurs at Nimbus, the change in operations is not expected to overwhelm the existing effluent system. Staff may have to increase the frequency of effluent pond cleanings because of the increased waste concentration. The quality of effluent water eventually returning to the American River is not expected to change as a result of the proposed upgrades.

It is important to note that changes to existing aquaculture programs (renovations, new construction) may trigger (administratively) the requirement for new and/or updated NPDES permits. Acknowledging that waste load (fish biomass) is not anticipated to change with the proposed alternatives, we assume that the increase in effluent removal efficiencies provided by the PRAS systems will result in net effluent "gains" to the overall aquaculture program.

5.5 Hatchery Operational Impacts/Husbandry

The production schedule will remain the same and is dependent on the Fall Chinook Salmon and steelhead run timing. The ability to chill water during incubation for Fall Chinook Salmon will protect these eggs and fry from rising temperatures in the future. The deep tanks will continue to provide early rearing space and current fish culture practices can continue.

As the fish outgrow the deep tanks, they will be transferred into the circular PRAS tanks. A small fish pump (e.g., 2.5-inch hose diameter) could be used transfer fish from the deep tanks to the outdoor circular tanks, significantly reducing the handling stress and staff labor required. Distances from the deep tanks to circular tanks may require pumping of fish onto a transport truck prior to their final delivery to the grow-out tanks. If enumeration of the fish is desired, a fish counter may be utilized in conjunction with the fish pump. Once fish have been transferred to the circular tanks, they will be grown to their target release size at which time they will maximize the biomass and DI capacity of the system. Truck loading for fish release will basically continue as the hatchery has previously operated, using fish pumps and dewatering towers with a few minor adjustments unique to circular tanks relative to traditional raceways.

Operation of the PRAS for egg incubation will require some additional training, but CDFW has expertise with these systems at other hatcheries. Care must be taken when treating eggs with any chemicals in a reuse system, and water quality should be closely monitored to ensure it remains acceptable for incubation requirements.

5.5.1 PRAS Circular Tank Operations

The final rearing tanks will operate as PRAS systems reusing 50 to 75% of their water flow. The hydraulic self-cleaning characteristics of the circular tanks will reduce labor associated with tank cleaning. Additional tank sweeper systems are also available and can further reduce staff labor associated with maintaining tank hygiene. Staff time will be required for monitoring PRAS components including routine water quality checks, flow adjustments, and monitoring LHO and CO_2 systems to ensure a high-quality rearing environment. Staff will make routine flow adjustments as fish grow to maintain a maximum velocity of approximately two body lengths/second (or as required for fisheries management objectives). Seine nets, clamshell crowders or other crowder types can be used to concentrate fish for collection and handling. Circular tank operations that include volitional releases are rare; technology and designs have not been widely adopted across the industry. In some cases, volitional releases can be allowed by removing the side box drain screen from the tank and diverting the discharge to the receiving water. However, not all fish within the tank will use this route, ultimately requiring at least some level of traditional harvest effort.

Transfer of fish between tanks and for truck loading will utilize fish pumps and hosing to minimize handling and stress on the fish and decrease physical labor for staff transferring fish between tanks or loading trucks. For transferring fish into other rearing tanks requiring enumeration, a fish counter can be included at the receiving tank to obtain an accurate inventory of the fish. For fish being loaded onto a transport tanker for stocking, a dewatering tower will allow for the removal of the water through a screen prior to the fish entering the fish transport tanker. This is consistent with current hatchery practices as well as industry standards and practices and allows the hatchery to quantify fish biomass based on water displacement in the fish transport tanker. The return of the water from the dewatering tower to the PRAS module sump will be necessary to maintain the water balance within the PRAS module. Another option is to increase the fresh make-up water flow to compensate for this water loss in the module during the fish pumping process.

5.5.2 PRAS Equipment

The PRAS provides tremendous benefits in reducing the water flow requirements to produce large numbers/biomass of fish while maximizing water quality. However, these systems are more complex and require additional skillsets to monitor and maintain the equipment to ensure reliable system operations for successful fish production. Hatchery production is seasonal and has designated periods when some PRAS modules may be empty. During these periods, staff can perform cleaning and disinfection, as well as any preventative or routine maintenance required. All PRASs should be programmed into the facilities maintenance and management system to schedule, perform, and document preventative and corrective maintenance.

5.5.3 Feeding

Early rearing feeding techniques in the deep tanks can continue using the hatchery’s standard feeding practices. Hatchery staff will need to transition away from the blower-style feeding systems typically used for linear raceways to a feeding system designed for circular tanks. Fish can be fed in circular tanks utilizing the simplest methods, ranging from hand-feeding to automated systems and the techniques may vary depending on the size of the circular tanks and staff preferences. In addition to staff preferences, there are pros and cons associated with the various feeding options. Hand-feeding requires more staff time compared to automated feeding systems as it is labor intensive but allows staff to observe fish feeding and overall behavior and health. Hand-feeding allows the staff to feed the fish to satiation and minimizes overfeeding reducing wasted feed and maximizing water quality. Automated systems require an initial cost for the purchase and installation of the system. The automated feeding systems provide feed intermittently throughout the day, including staff non-duty times, to maximize growth. Automatic feeder systems reduce staff labor but as a result reduce the mandatory time spent observing fish; feeders also require routine adjustment and maintenance to ensure the correct amount of feed is distributed and all feeders work as intended. It should be noted that hand and automatic feeding systems are not mutually exclusive. Even with automatic feeding systems, culture operations should still involve regular monitoring of fish and their feeding response throughout the day.

5.6 Biosecurity

The goal of biosecurity measures is to minimize the risk of pathogens entering the facility and spreading between rearing areas at the facility. Nimbus Fish Hatchery reported several pathogens of concerns at the facility. This included Columnaris (*Flavobacterium columnare)*, bacterial coldwater disease (causative agent *Flavobacterium psychrophilum*), Infectious Hematopoietic Necrosis virus (IHNv), fungus (*Saprolegnia* spp.) and a variety of parasites associated with the surface water supply. The most likely pathways for pathogens to enter the Nimbus Hatchery and spread through the facility are through the incoming water supply or environmental exposure within the hatchery.

5.6.1 Incoming Water Supply

The Nimbus Hatchery currently has limited measures to prevent pathogens from entering the facility. However, the recommended alternatives improve biosecurity by extending the use of UV treated water to the grow-out systems as well as the hatchery buildings, including a more permanent solution for Hatchery Building 1. These additions would reduce the pathogen loads and potential for disease and/or parasite outbreaks at the hatchery.

5.6.2 Environmental Exposure/Bio Vectors

The existing facility has several areas that are potential pathways for pathogens due to environmental exposure. The existing concrete raceways are enclosed by perimeter fencing with bird wires overtop, but these structures are minimally effective in excluding otters, raccoons, and avian predators from accessing the raceways. The recommended alternatives reduce the risk of pathogens entering the rearing areas by reducing environmental exposure. Implementing PRAS in covered structures will limit potential pathogen vectors, such as birds, otters, etc., from entering the rearing vessels. Predators can be a significant source of stress, and they can transmit pathogens into the facility.

5.7 Water Quality Impacts

The recommended alternatives will improve the water quality within the existing rearing vessels. Treatment of the incoming water will result in higher quality water at the start of the culture process, leading to cleaner water in the effluent relative to current conditions. The addition of chilling capability throughout the hatchery will provide water temperatures within a healthy range for the fish minimizing stress and the potential for fish health issues. Replacing the existing concrete raceways with dual-drain circular tanks can improve the water quality of the rearing environment. Dual-drain circular tanks provide a completely mixed environment as opposed to a raceway that has a gradient of high to low dissolved oxygen (DO) along its length. This characteristic of circular tanks makes the entire tank volume available to the fish, instead of fish crowding at a raceway’s head end, thereby not using the entire raceway volume. The dual-drain system in circular tanks aids in waste removal, allowing for more effective removal of solid waste and uneaten feed. This can contribute to better overall water quality in the rearing vessels.

The other PRAS equipment will also improve the water quality within the system. The microscreen drum filters will remove the solids in the water. The LHOs will ensure the dissolved oxygen levels enter the tanks at saturation or higher. The carbon dioxide strippers will remove dissolved carbon dioxide as well as other undesirable gases, and the UV unit will reduce the pathogen load of the water that returns to the tanks. Additionally, installing a rigid roof structure with bird netting will reduce heat gain during the summer months and algae growth in the rearing tanks.

Each PRAS module will concentrate the fish waste into smaller flows prior to the water entering the settling ponds. This will reduce the volume of water the settling ponds are handling but increase the concentration of biological waste. Water will still percolate through the ground into the American River, but staff may have to increase the frequency of effluent pond cleanings in response to the more concentrated waste streams. Ultimately, the proposed upgrades will have little to no impact on the water quality discharged into the American River.

6.0 Alternative Cost Evaluation

6.1 Introduction

McMillen has utilized historical costs as a self-performing general contractor in the performance of similarly-technical projects, as the basis of our Preliminary Concept Planning – Opinion of Probable Construction Cost (OPCC) estimate for this Project. Additionally, McMillen has solicited pricing or utilized recently received material quotes for similar materials and equipment or components. The appropriate overhead and profit markups have been included in the project pricing. The detailed cost estimates, including assumptions and inflation information are presented in Appendix F.

6.2 Estimate Classification

This OPCC estimate is consistent with a Class 5 estimate as defined by the Association for Advancement of Cost Engineering (AACE) classification system, as shown in Table 6-1 below. For purposes of this project, McMillen has utilized an accuracy range of -30% to +50% in the estimates presented in Table 6-2.

Table 6-1. AACE Class 5 Estimate Description (Source: Association for Advancement of Cost Engineering).

Criteria	Details
Description	Class 5 estimates are generally prepared based on very limited information and subsequently have wide accuracy ranges. As such, some companies and organizations have elected to determine that due to the inherent inaccuracies, such estimates cannot be classified in a conventional and systemic manner. Class 5 estimates, due to the requirements of end use, may be prepared within a very limited amount of time and with little effort expended—sometimes requiring less than an hour to prepare. Often, little more than proposed plant type, location, and capacity are known at the time of estimate preparation.
Level of Project Definition Required	0% to 2% of full project definition.
End Usage	Class 5 estimates are prepared for any number of strategic business planning purposes, such as but not limited to market studies, assessment of initial viability, evaluation of alternate schemes, project screening, project location studies, evaluation of resource needs and budgeting, long-range capital planning, etc.

Criteria	Details
Estimating Methods Used	Class 5 estimates virtually always use stochastic estimating methods such as cost/capacity curves and factors, scale of operations factors, Lang factors, Hand factors, Chilton factors, Peters-Timmerhaus factors, Guthrie factors, and other parametric and modeling techniques.
Expected Accuracy Range	Typical accuracy ranges for Class 5 estimates are -20% to -50% on the low side, and +30% to +100% on the high side, depending on the technological complexity of the project, appropriate reference information, and the inclusion of an appropriate contingency determination. Ranges could exceed those shown in unusual circumstances.
Effort to Prepare (for US$20MM project)	As little as 1 hour or less to perhaps more than 200 hours, depending on the project and the estimating methodology used.
ANSI Standard Reference Z94.2-1989 Name	Order of magnitude estimate (typically -30% to +50%).
Alternate Estimate Names, Expressions, Synonyms:	Ratio, ballpark, blue sky, seat-of-pants, ROM, idea study, prospect estimate, concession license estimate, guesstimate, rule-of-thumb.

6.3 Cost Evaluation Assumptions

The following assumptions were made while developing the cost estimates for this alternatives analysis:

- The cost estimate is at a Class 5 level with an accuracy range of -30% to +50% and includes a 25% contingency. This range accounts for current inflation variability within aquaculture projects, unforeseen conditions, and anticipated cost escalation leading up to the projected construction year.
- Prevailing wages are provided as a general increase based on past construction pricing.
- All Division costs are rounded up to the nearest $1,000.
- Length and area dimensions for the estimate were derived from scaled AutoCAD drawings of the facility and the property. Survey was not utilized for this initial estimate.
- Geotech investigation cost assumes seven bore holes (20 feet deep), material testing, piezometer installation, and a written report.
- Topographic survey cost assumption is based on $1,000/acre.
- Building joist/eave height will be 18 feet.

- Site geotechnical properties have not been evaluated but are assumed to be good for construction of the hatchery.
- A facility condition assessment was performed for the Nimbus Fish Hatchery in 2022 by Terracon (Terracon Consultants, Inc., 2022). The assessment included an inventory of all facilities and equipment, code evaluations, and upgrades required to meet the assessment including the detailed replacement value. The cost of all work items generated was $1,555,047 in 2022 dollars. The work items in the Terracon facility condition assessment are not included within this report, costs, or evaluation of facilities. Some work items from the Terracon facility condition assessment may be resolved as part of the proposed upgrades at the Nimbus Fish Hatchery, while others may still need to be addressed. The upgrades in the Terracon reports may be included in future design efforts for each facility at CDFW direction.
- PRASs will be in enclosed, non-conditioned areas with sheet metal systems walls and doors. Ventilation for humidity will be included.
- Three 500kW backup generators are proposed for new equipment; it is assumed that there is adequate backup power capacity for existing equipment and facilities.
- It is assumed that the existing abatement ponds will be maintained and are of adequate capacity to be used for the new facilities.
- Additional division specific cost evaluation assumptions may be found in Appendix F.

6.4 LEED Assessment

RIM Architects (RIM) and STŌK have reviewed and assessed this facility’s location along with reviewing the combination of state law and Leadership in Energy and Environmental Building (LEED) eligibility requirements. From this review, it is determined that this location is not eligible or required under state law to pursue LEED due to the lack of human occupancy and/or square footage requirements in the proposed structures. There is insufficient scope to pursue LEED certification. Refer to Appendix H for more information.

6.5 Net Zero Energy Evaluation

This small site has high energy demands and is bordered by the American River. While there is potential for rooftop photovoltaic (PV) installations on existing buildings, the overall size and energy requirements make locating 100% of the PV requirements challenging. Additional space will likely be needed, with only 29% of the offset potential currently achieved. Achieving net zero would necessitate covering approximately 300,000 square feet (6.9 acres) of greenspace with PV panels.

6.6 Alternative Cost Estimate

The following table illustrates the estimated costs for the proposed improvements depicted within the figures in Appendix C. The complete cost estimate can be found in Appendix F.

Table 6-2. Alternative Cost Estimate

Item	Estimate ($)
Division 01 – General Requirements	5,352,000
Division 02 – Existing Conditions	391,000
Division 03 – Concrete	1,461,000
Division 05 – Metals	170,000
Division 13 – Special Construction	16,109,000
Division 23 – Mechanical & HVAC	286,000
Division 26 – Electrical	2,900,000
Division 31 – Earthwork	532,000
Division 32 – Exterior Improvements	255,000
Division 40 – Mechanical Piping and Yard Piping	4,654,000
Division 44 – Pumps	127,000
2024 CONSTRUCTION COST	**26,758,000**
Construction Contingency	8,028,000
Overhead	1,927,000
Profit	2,569,000
Bond Rate	322,000
2024 CONSTRUCTION PRICE	**44,956,000**
Design, Permitting and Construction Support	6,744,000
Geotechnical	25,000
Topographic Survey	5,000
PROJECT TOTAL	**51,730,000**
Accuracy Range +50%	72,422,000
Accuracy Range -30%	36,211,000
Photovoltaic (Full kW Required)	21,699,900
Photovoltaic (Roof KW Available)	2,170,800

7.0 Nimbus Fish Hatchery Environmental Permitting

7.1 Anticipated Permits and Supporting Documentation

The proposed Project would involve the modification to the existing hatchery and associated infrastructure. It would potentially involve work near the existing water supply/intake/pumpstation, requiring instream construction, for the hatchery operations. A list of anticipated permits, agency review time, submittal requirements, and supporting documentation for the proposed project regardless of which alternative is selected are summarized in Table 7-1, Table 7-2, and Table 7-3. The review timeframes are estimated and are based on the recommendations presented in permit guidance documentation and experience with other permitting projects in California.

We reviewed the location through online mapping tools (U.S. Fish and Wildlife Service [USFWS] Information Planning and Consultation [IPaC] and California Biogeographic Information and Observation System [BIOS]) to determine if species listed under the Endangered Species Act (ESA) and the California Endangered Species Act (CESA) potentially occur at the site. The results indicated that the site has the potential for species to be present identified as endangered or threatened. The site does not contain critical habitat. The results of these mapping tools indicate that a Biological Assessment of the area would need to be prepared prior to consultation with the USFWS, National Oceanic and Atmospheric Administration (NOAA), and other state agencies.

The list is developed at a high level and additional permits may need to be assessed as the project is advanced.

Table 7-1. Anticipated Federal Permits and Approvals for Selected Location

Agency and Permit/Approval	Submittal / Document Type	Supporting Documentation	Anticipated Time Frame	Notes
USFWS National Environmental Policy Act (NEPA) Compliance	Environmental Assessment	Analysis of potential impacts on various natural resources, Design Package	12 – 18 months	Evaluation of the selected alternative to identify if there would be a significant impact

Agency and Permit/Approval	Submittal / Document Type	Supporting Documentation	Anticipated Time Frame	Notes
U.S. Army Corps of Engineers (USACE) Clean Water Act (CWA) Section 404 - Nationwide Permit Authorization	Pre-Construction Notification Application	Wetland and Stream Delineation, Design Package	3 months	Required if jurisdictional waters of the U.S. or wetlands are affected by the project area
USFWS ESA Section 7 Consultation	Biological Assessment	Field surveys of affected area, Design Package	4 months	The site has potential for species listed under the ESA to occur
National Oceanic and Atmospheric Administration (NOAA) Section 10(a)(1)(A) of the ESA	Application	Supplemental information to include description of proposed project, analysis of potential take and potential impact to species, proposed minimization and mitigation measures, and funding source	4 months	Authorization for scientific purposes or to enhance the propagation or survival of an endangered or threatened species

Table 7-2. Anticipated State of California Permits and Approvals for Selected Location

Agency and Permit/Approval	Submittal / Document Type	Supporting Documentation	Anticipated Time Frame	Notes
Lead Agency TBD California Environmental Quality Act (CEQA)	Environmental Impact Report	Analysis of potential impacts on various natural resources, Design Package	12 – 18 months	Required for issuing State permits. Potential to be coordinated with the NEPA compliance for efficiency

Agency and Permit/Approval	Submittal / Document Type	Supporting Documentation	Anticipated Time Frame	Notes
California Department of Fish and Wildlife (CDFW) California Fish and Wildlife Code Section 2081 Incidental Take	Application	Supplemental information to include description of proposed project, analysis of potential take and potential impact to species, proposed minimization and mitigation measures, and funding source	4 months	Required for the authorization to take any species listed under the California Endangered Species Act
California Department of Fish and Wildlife (CDFW) California Fish and Wildlife Code Section 1600 Lake and Streambed Permits	Application/ Notification	N/A	1-3 months	Required for hatchery intake diversions
Central Valley Regional Water Quality Control Board (RWQCB) 401 Water Quality Certification	Application	Wetland and Stream Delineation USACE Review NEPA/CEQA Compliance	3 months	Required if jurisdictional waters of the US or wetlands are affected by the project area
California Office of Historic Preservation Section 106 Review	Concurrence Request Letter	Cultural Resources Survey, Design Package	3 months	Required as part of the NEPA/CEQA process

Agency and Permit/Approval	Submittal / Document Type	Supporting Documentation	Anticipated Time Frame	Notes
California Division of Water Rights Water Rights	Application or Transfer	N/A	4 months	N/A
California State Water Resources Control Board (SWRCB) National Pollutant Discharge Elimination System (NPDES)	Application (Note facility renovation/construction may trigger "New Source" permit for NPDES)	N/A	1 month	Required if hatchery effluent is discharged to a jurisdictional waterway
SWRCB Construction General Permit	Application	Stormwater Pollution Prevention Plan (SWPPP)	2 months	Required if construction activities disturb greater than one acre

Table 7-3. Anticipated Sacramento County Permits and Approvals for Selected Location

Agency and Permit/Approval	Submittal / Document Type	Supporting Documentation	Anticipated Time Frame	Notes
Sacramento County Building Services Department Construction Permits	Grading, Building, Electrical, Mechanical, Pumping Applications	Project Summary and Design Package	2 months	N/A

7.2 National Pollutant Discharge Elimination System (NPDES) Permitting

The American River Hatchery and Nimbus Hatchery share the same NPDES permit and, for that purpose, are collectively referred to as a single facility. The facility is classified as a cold water Concentrated Aquatic Animal Production (CAAP) facility and is eligible to operate under General Order R5-2019-0079 issued by the Regional Water Quality Control Board, Central Valley (Region 5), and NPDES Permit No. CAG135001.

Wastewater is discharged through the following outfalls:

- Outfall 001: Latitude: 38° 38' 07.00" N and Longitude: 121° 13' 13.27" W.
- Outfall 002: Latitude: 38° 38' 05.90" N; and Longitude: 121° 13' 35.29" W.
- Outfall 004N: Latitude: 38° 38' 01.47" N; and Longitude: 121° 13' 48.52" W.
- Outfall 004S: Latitude 38° 37' 59.70" N; and Longitude: 121° 13' 46.90" W.

The permit identifies formaldehyde and chlorine as potential pollutants from the hatchery. The following limitations for formaldehyde and chlorine effluent are specified:

- Formaldehyde: 0.65 mg/L (monthly average), 1.3 mg/L (daily maximum)
- Chlorine: 0.018 mg/L (daily maximum)

7.3 Water Rights

Water rights documentation can be obtained from the client if requested by an agency.

8.0 Conclusions and Recommendations

This report provides valuable information on the impacts that the Nimbus Hatchery could experience as a result of climate change and provides modifications that can be made to increase the resiliency of the hatchery. Based on historic trends and the general climate impacts experienced throughout California's Central Valley, air and water temperatures are expected to increase.

To meet CDFW's goal of continuing to provide recreational fishing opportunities for the public and for the conservation of endangered or threatened species as the climate changes, the resiliency of existing hatcheries will need to be increased. Increased resiliency will also require updating existing infrastructure that is nearing the end of its effective lifespan.

Some recommendations that would help to achieve this goal include the following:

- Dredging and inspecting current intake structures, then installing an automatic traveling screen for the 42-inch intake to reduce debris in all water sources to the hatchery.
- Inspecting and replacing valves for the hatchery's water supply, improving flow control and isolation ability.
- Replacing raceways with circular tank PRAS moules, including water chillers that reduce the risk of emergency fish evacuations during periods with increased water temperatures.
- Adding chilling capacity and retrofitting existing incubation systems with water reuse capabilities in Hatchery Building 2.
- Installing existing filtration and UV disinfection equipment for Hatchery Building 1 while installing new chilling equipment to maintain low water temperatures for sensitive life stages of Chinook Salmon and steelhead.
- Providing all grow-out PRAS rearing systems with solid roof structures overhead to reduce the impacts of increased air temperatures for both the fish and the employees.
- Promoting public engagement with constructed viewing areas of new grow-out PRAS area.
- Installing solar panels atop new structures will offset some of the power demands associated with new hatchery equipment.

The proposed upgrades to the Nimbus Hatchery would have negligible impacts on the natural resources in the surrounding area. All improvements would occur within currently developed areas, which lessen the permit requirements. The total cost estimate of the proposed design modifications is $51,730,000.

9.0 References

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